The Impact of Biochar on the Soil

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In the present paper are presented the experimental results of biomass gasification, the biochair was produced from vineyards by controlled pyrolysis at 750 °C, in order to increase the fertility of soils, it was found the increase of the fertility produced by the development of the vegetables in the soil to which was added biochar. Soil was added to soil 4 g/dm^3 biochar, 8 g/dm^3 biochar, the soil had no high humidity, was taken at a time when it had not rained for at least one week, the soil pH was 8, in the soil with 8 g/dm^3 biochar the plants increased compared to the soil with 4 g/dm^3 and the soil without biochar. The biochar resulting from pyrolysis and gasification processes is a valuable amendment to agricultural soils and an efficient and economical way to seize carbon. Using biochar it is possible to increase the diversity of agricultural land in an environmentally sound way in areas with depleted soils, limited organic resources and insufficient water for development. Helps to soil carbon sequestration with negative CO_2 balance, increases the productive potential of agricultural ecosystems.

Keywords: biomass, micro-gasification energy potential, biochar

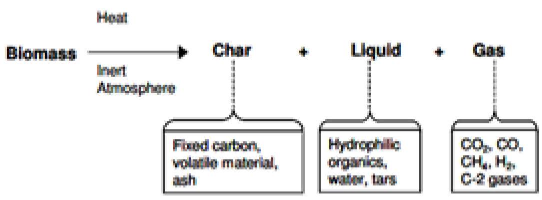
The cuttings of the cut vine have a high energy value (2000 kg / ha with an energy potential of 21.5 [GJ / ha.an]). The utilization of the vine chords is done by thermo-chemical gasification with the TLUD process (gas generator directly coupled to a special burner for low calorific fuel) in energy modules producing thermal energy and 14% biochar [1].

The biochar is a solid, porous, fine-grained material produced by biomass oxidation under substoichiometric conditions and can be characterized as a thermally modified biomass [2]. The biochar can remain in the soil without being biologically degraded [3]. The persistence of the biochar facilitates soil dynamics by reducing the contribution of other chemical amendments or fertilizers [4].

The biochair is a byproduct of the pyrolysis processes and / or the thermo-chemical gasification of the vegetal biomass [5]. After the pyrolysis process there remains a relatively large amount of unconverted carbon, which in the oxidation and gasification processes is oxidized and reduced to a large extent; what remains is the bio-carbon that has its composition: carbon, oxygen, hydrogen and ash, which is important for the recycling of minerals specific to the ecosystem of viticulture [6,-9].

Pyrolysis is a thermo-chemical decomposition process in which the organic material is transformed into a carbon rich solid and volatile matter by heating in the absence of oxygen [10].

The biochar has high carbon content and can contain about half of the total amount of carbon in the original organic material. The process is represented in equation 1.



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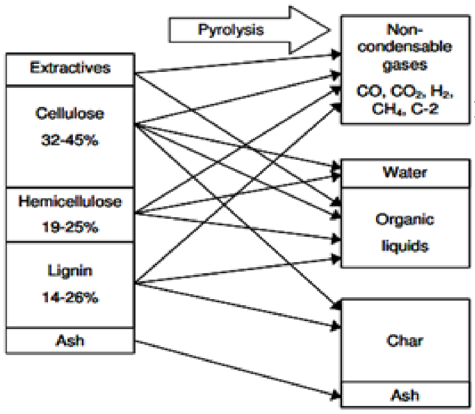

Fig. 1 Simplified representation of biomass pyrolysis [10]

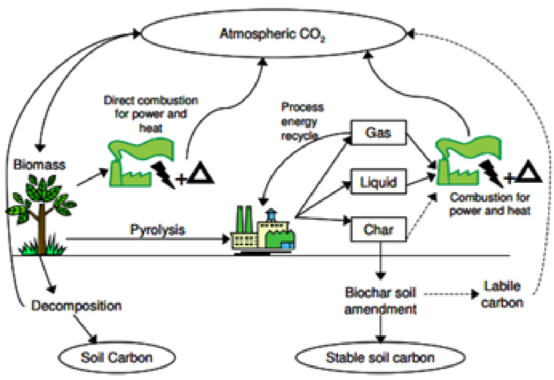

Fig. 2 Scheme Showing Main Carbon Flows Associated with Biomass Pyrolysis [13]

The main carbon flows associated with biomass pyrolysis are shown in figure 2. Carbon is extracted from the atmosphere as carbon dioxide by plant cultivation by photosynthesis and assimilated into biomass. In the natural processes of death and decomposition, carbon is released as carbon dioxide back into the atmosphere in a short time [24-29]. Biomass has an energy value almost related to its carbon content [11]. This energy can be released by combustion and used for purposes such as power

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generation or heating. Coal is thermochemically oxidized to carbon dioxide and returns to the atmosphere.

The available biomass energy is renewable and carbon-free [12]. If biomass is pyrolyzed, the carbon and energy value is divided between the three product streams: carbon, liquid and gas. The total mass of the products will be equal to the mass of the raw material if it is correctly calculated and the total carbon content of the products will be equal to the biomass. As with biomass fodder, charcoal and liquid products have energy values correlated with their carbon content. The release of this energy through combustion can again be considered as renewable and carbon-free; carbon has returned to the atmosphere because carbon dioxide is the same as it would result from decomposition of biomass. If the product is not burned but retained in a way that the carbon in it is stable, then the carbon can be assimilated to the carbon dioxide removed from the atmosphere and seized. The gaseous product is typically a mixture of carbon dioxide (9-55%), carbon monoxide (16-51%), hydrogen (2-43%), methane (4-11%) and small amounts of higher hydrocarbons. The carbon stored in char is equivalent to the carbon dioxide released into the atmosphere [13].

A comparison was made between different models (Best, Haloclean, Biotherm, McCarl) to calculate the energy product and the net effect on carbon dioxide; these are shown in figure 3. Values differ for products obtained through pyrolysis processes. The smallest electricity is produced by the slow pyrolysis process in which much of the energy value of the feedstock is blocked in the char product [14]. The net effect on carbon dioxide is negative for all processes, showing that there is a benefit to the atmospheric carbon dioxide levels, in each case resulting from the combination of carbon sequestration in char and avoiding emissions from the use of fossil fuels. The benefit rate is the highest for slow pyrolysis, where most carbon is retained in char, and at least for fast processes with low yields char, especially for the McCarl model, which consumes much of the char product for process energy [10].

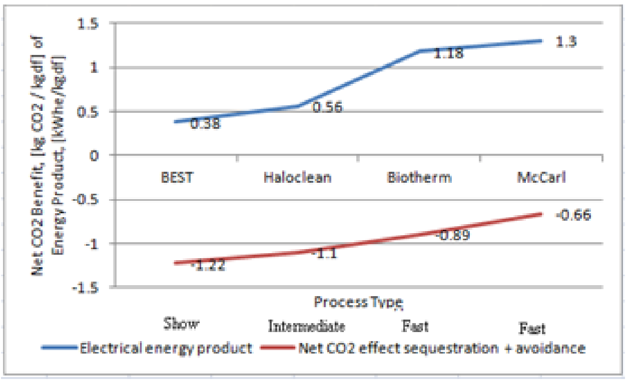

Fig. 3 Comparison of Pyrolysis Processes: Energy Product and Net CO_2 Benefit Display

Figure 3 shows the net effect on carbon dioxide and electricity production. Direct combustion of biomass raw materials would give more electricity than pyrolysis. Pyrolysis energy production is reduced by the energy requirement of the process, by energy losses.

Model comparisons (Best, Haloclean, Bioterm, McCarl) suggest that slow and intermediate pyrolysis processes provide the greatest net benefit for atmospheric carbon dioxide due to carbon sequestered char but have low electrical power. Pyrolysis energy production is reduced by the energy requirement of the process, the energy losses and the energy value of retained char. The comparison with the net effect of carbon dioxide shown in figure 4 suggests that in relation to energy production, rapid pyrolysis has a greater effect on carbon dioxide on the amount of retained char.

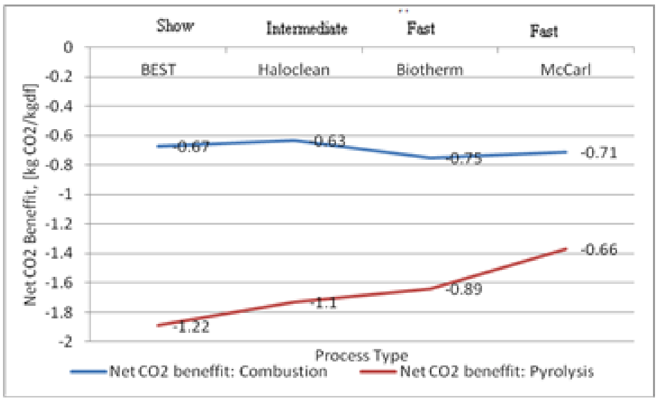

Fig. 4 The biomass combustion benefit compared to pyrolysis processes

Experimental part

Materials and methods

From the experimental tests carried out to determine the bio-charging capacity with TLUD energy modules, it was found that the biochair produced in metal wall reactors had the following chemical composition: carbon 77%, oxygen 16%, hydrogen 4% and ash 3% [9].

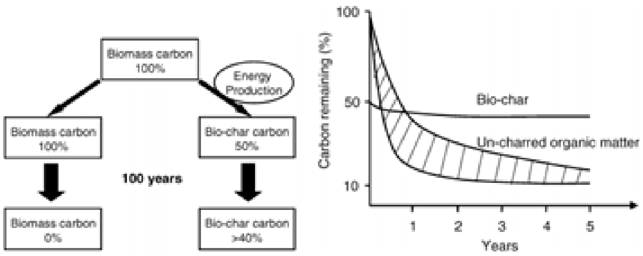

Fig. 5 Schematics for biomass or bio-char remaining after charring and decomposition in soil. (a) Carbon remaining from biomass decomposition after 100 years; Carbon remaining after charring or pyrolysis [19].

Conversion of biomass into biochar modifies transformation dynamics in carbon sequestration. After loading about 50% of the carbon contained in the biomass, it is immediately released, leaving a stable bio-char residue (fig. 5). The material that decomposes into the soil will initially release C slower over time. Release C continues until all C is lost and can be estimated to be less than 10-20% C remaining in agricultural soil after 5-10 years.

Figure 6 shows the carbonization process. As the flame progresses, it heats the wood and removes the volatiles, leaving the char carbonate as a residual solid. All processes involved in pyrolysis, gasification, and combustion can be seen in a flaming match (fig. 6).

From a statistical analysis of global results, a significant positive effect resulted: a 12% increase in agricultural output [15].

The TLUD (Top-Lit UpDraft) devices feature flaming pyrolysis, a unique combustion process that produces char at the same time as the pyrolytic wood gas is released from the biomass. Cooking is accomplished by secondary combustion of the pyrolytic gases. In a typical TLUD, the pyrolysis front moves downward 5 to 20 mm per minute,

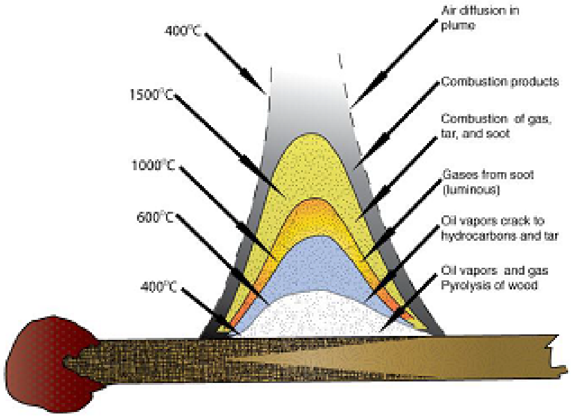

Fig. 6 A match converts wood into char as it burns [17]

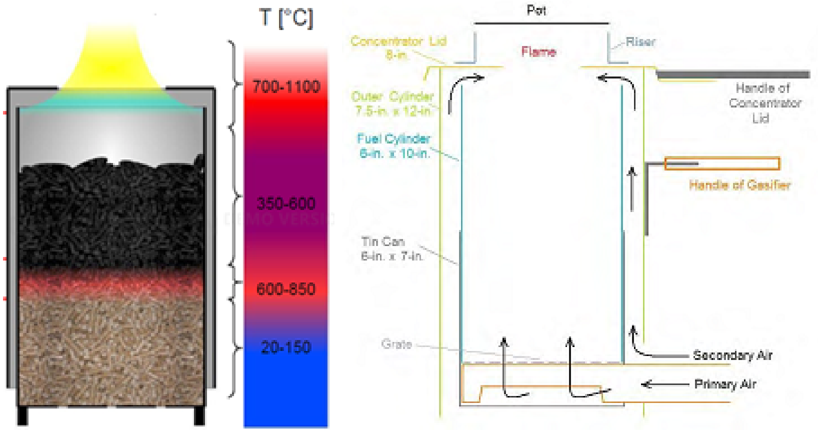

Fig. 7 Vertical section of the TLUD Gasifier [9]

Fig. 8 Biochar

depending on the nature of the fuel and the amount of available primary air (fig. 7) [1, 9].

During the period when the cucumber cultures were monitored, meteorological parameters were monitored by the meteorological station at the Faculty of Biotechnical Systems Engineering at the Politehnica University of Bucharest [20].

Results and discussions

Table 1 shows the chemical composition for the vine chords with which the reactor was loaded and the biochar resulting from gasification. By difference, the composition of the biomass which is fully converted into the fuel gas has been calculated.

Biochar (fig. 8) is a solid, porous, fine-grained material, is an active sterile coal with a *p*H> 9 and a high adsorption capacity, usable as an agricultural amendment for soil fertility, as an additive in animal feed, and as a filtering material for air, gas and water and for sequestration of carbon in the soil, is similar to coal produced by oxidation of biomass under substoichiometric conditions. Traded at 400..1000 euro / t, zero or negative costs can be obtained for the heat produced. From the biomass carbon content of 30-50% is scraped into the soil. 15-30% is obtained depending on the biomass and the thermal regime. A biochar quality, usable as an agricultural amendment, occurs in installations with automatic controlled pyrolysis process to ensure the optimum regime

The biochar can remain in the soil without being biologically degraded. The persistence of the biochar facilitates soil dynamics by reducing the intake of chemical fertilizers.

A ton of 10% humidity horns has a potential energy of about 16 GJ/t of which, in the case of the production of 140 kg of biofuel, 12 MJ/t or 3.31 MWh/t of thermal energy corresponding to combustion of 374 L of diesel [1].

Annually, one hectare produces at least 2000 kg/year of vineyards with 40% humidity, of which by drying up to 10%, 1340 kg/year of potentially transformable biomass is obtained. The annual vineyard strain on a vineyard has a potential energy of 21.5 GJ/ha. And it can produce about 190 kg / ha of bio-charcoal and 4.44 MWh/ha of thermal energy, which would be produced by burning 500 L of diesel [15].

Table 1
CHEMICAL COMPOSITION: VINE ROOTS, BIOCHAR AND GASIFIED BIOMASS

Size	UM	Vineyards	Biochar	Gasified biomass
Relative weight	%	100	14	86
Carbon	%	42.69	77	37.11
Oxygen	%	39.71	16	43.56
Hydrogen	%	5.26	4	5.46
Ash	%	2.33	3	2.24
The water	%	10	0	11.63

The main objective of using biomass for energy production and biochar is the ecological one followed by the economic one based on the principles of the sustainable development of agriculture [16, 18, 20-26]. A part of the carbon in the vine rocks remains in the biochar and is introduced into the soil where the decomposition period is very high 1000 ... 1200 years, so it is a long-term sequestration process of carbon in the soil. When analyzing the carbon in the biochar represents about 25% of the carbon in the gorse vineyards, which leads to a first result: the theoretical CO_2 balance is negative and a mass of 115 kg / ha of carbon can be seized annually, equivalent to 378 kg / ha.an CO_2 with drawn from the atmosphere. One kilogram of carbon of the biochar reduces the mass of atmospheric CO_2 by 3.66 kg. At a 70% carbon concentration in the bio-tree, one hectare of agricultural land could seize 1,078 t CO_2 / ha [15]. From one hectare of vineyards on which 4000-5000 hubs are produced, the annual cuts from each hub yield 0.6 ÷ 1 kg of cords, so at least 3000 kg / ha cut strands with a relative humidity of about 40 %. By natural drying the chopped strands reach 20% moisture and reach a very good cellulose fuel mass of about 2200 kg / ha. From this gasification gas can produce 4800 m^3 of gas with which a thermal energy of 6, 60 MWht can be produced. In Romania, for wood waste from the cuttings of orchards in orchards, forestry, sawmills, etc., it can be estimated that the price of the fuel that is introduced into the gas, averages 10 euro / t. A primary energy price of up to euro 0.6 / GJ results [15].

Dryers are very heat-consuming, which leads to high production costs for their products. Reducing the cost of heat reduces overall costs and increases the competitiveness of dehydrated products. The use of locally available biomass can ensure a significant reduction in production costs and a clash of energy independence [24-26]. The efficient, both energy and ecological use of residual agricultural biomass consists in the simultaneous generation of energy and biochar in the same thermo-chemical process.

Within the Department of Biotechnical Systems of U.P.B. experimental activities were carried out for the gasification of the biomass of vineyards with the production of biochar under controlled conditions.

At the beginning of the experimental activity, the vegetal biomass had initially a moisture content of 20%; the biomass was dried to 10% humidity by means of a dryer in the faculty laboratory (fig. 10). The drying time was one hour.

TLUD gas was placed on an electronic weighing scale to measure the mass change during gasification (fig. 9),

Fig. 9 TLUD Test Stand

Fig. 10 Dryer Biomass

the gasogen reactor was filled with 1000 grams of grape vines with an average humidity of 10%. After 25 min of gasification where the pyrolysis temperature was measured with a thermocouple at 700 °C, there remained 150 g of bio-ash and ash.

At the time of discharging the bio gas from the gas, it had a red color similar to the hot coal, due to the pyrolysis temperature above 650 °C.

To preserve plant beneficial properties, the biochair was quenched with water stopping its oxidation.

For the experimental use of the biochar in order to increase soil fertility, the following were used: nutritional cuvettes; vegetable soil with a *p*H of 8; electronic scales for dosing the earth and the biochar; cucumber seeds; biochar obtained from vineyards held for 10 hours in a closed container filled with bovine urine to feed the biochar with nutrients.

The biochar was applied in alveolar trays as follows: first on the left side was the soil without biochar, the last row on the right side with 4 g / dm^3 biochor, and in the middle alveoli was the soil with 8 g / dm^3 biochar (cuvettes will serve as nutritious pots, 1 cell = 0.1 dm^3) (fig. 11);

- the soil did not have a high moisture content, being taken over at least one week, the pH of the soil was 8;
- the quantities of soil were weighed and biochar with the help of an electronic weighing machine, were introduced into the alveoli, the plants were planted at a depth of 2 cm, the biochar is introduced in the middle of the alveoli, i.e. around the root zone of the plants.
- Watering water has been applied gradually depending on the degree of development of plants that require rooting and absorption time;
- the water is not chlorinated, it is kept in a container at ambient temperature
- after sowing, the trays are kept under observation in a constant temperature environment and natural lighting;

Plant development monitoring

- the planting time of the plants was 3 days.
- the ambient temperature was between 23 and 25.8 °C (fig. 12, table 2) .
- as a visual observation after 4 weeks of growth, the biochar applied in 4 and 8 g / dm^3 respectively had the expected result of increasing plant growth. At the beginning

Fig. 11 a Cucumber at five days after sowing (27.09.2017)

Fig. 11 b Cucumber at one month after sowing (17/10/2017)

of the experiment no different increases were observed on the monitored rows (fig. 11 a), but after a month, differences between the blank row and rows of 4 g and 8 g biochar. Biochar site added in some proportions, may lead to the development of plants.

It can be seen that the temperature varied between 6 and 25.8°C, and the rainfall fell on October 10 in small quantities (0.2 mm). The soil was dry.

Table 2 presents the results of the statistical analysis performed on the basis of meteorological parameters recorded by the weather station. The amount of rainfall

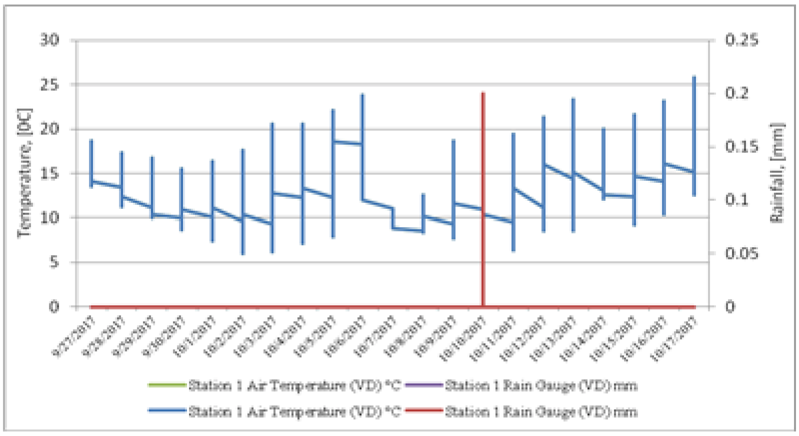

Fig.12. Graphical representation of rainfall and temperature values recorded in Bucharest by the weather station (AWS / EV) (27.09-17.10.2017)

Table 2
STATISTICAL ANALYSIS BASED ON METEOROLOGICAL PARAMETERS

Summary statistical	Air temperature [^{0}C]	Rain gauge [mm]
Mean	13.8	
Minimum	6.0	
Maximum	25.8	
Sum		0.2

recorded during the period when cucumber cultures were monitored was 0.2 mm, it did not rain the soil was dry.

Conclusions

The conversion of biomass into thermal energy with the TLUD process allows simultaneous generation of thermal energy and biochar. Energy reactor modules with metallic reactor are recommended where on average 14% of the used bark can be obtained;

The use of biomass as a renewable energy source can be optimized as a global effect by simultaneously producing heat and biochar;

Biochar is a by-product, with a weight of 10-20%, of the primary pyrolysis processes from biomass thermo-chemical gasification processes;

The biochar contains about 75% carbon and has a specific adsorption area of 250-350 m^2 / g;

The biochar gives back the soil the microelements lost during the plant growing period, thus reducing soil impoverishment in nutrients;

The incorporation into the soil of 190 kg / ha of a biochar corresponds to the reduction of the atmospheric CO_2 by 378 kg / ha, contributing to the reduction of the carbon mass in the atmosphere by the negative carbon balance;

Producing energy from biomass producing biofuels can also help reduce greenhouse effect and increase the productive potential of agricultural land;

Soil was added to soil 4 g/dm^3 biochar, 8 g/dm^3 biochar, the soil had no high humidity, was taken at a time when it had not rained for at least one week, the soil pH was 8, in the soil with 8 g/dm^3 bio-plant the plants increased compared to the soil with 4 g/dm^3 and the soil without bio-charge. Biochar can play a major role in extending options for sustainable soil management by improving existing practices not only to improve soil productivity but also to reduce nutrient loss by leaching it into groundwater.

Biochar is increasing the number of microorganisms beneficial to the soil. Biochar can become a true colony of microorganisms.

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